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MARTIAN LAVAS: THREE COMPLEMENTARY REMOTE SENSING TECHNIQUES TO DERIVE FLOW PROPERTIES: R. Lopes-Gautier (Jet Propulsion Laboratory, California Institute of Technology, MS 183-601, Pasadena CA 91109), B. C. Bruno, G. J. Taylor, S. Rowland (Planetary Geosciences, Dept. of Geology and Geophysics, University of Hawaii, Honolulu HI 96822) and C. R. J. Kilburn (Dept. of Environmental Sciences, University of Lancaster, Lancaster, UK)

Several remote sensing techniques have been developed to determine various properties of lava flows. We are currently focusing on three such techniques to interpret Martian lava flows on Alba Patera, which are based on measurements of (i) distal flow lobe widths which can be used to infer silica content (1); (ii) convolution of flow margins which can distinguish between pahoehoe and a'a types of basaltic flows (2); (iii) final flow field dimensions which can be combined with ground slope to derive effusion duration and average effusion rate (3). These methods are extremely complementary and together provide a more significant and complete understanding of extra-terrestrial lava flows. However, each of these techniques have specific and distinct data requirements.

**Distal flow lobe widths (1):** Distal flow lobes represent the arrest of free-flowing isothermal liquids on a slope. As such, their widths reflect rheological properties, which can, in turn, be related to silica content (Fig. 1). However, this technique cannot be confidently applied to flows on shallow slopes, because in these cases the flow margin tends to follow minor topographic irregularities. Wadge and Lopes (2) defined the lower limit of slope to be at least 0.6 degrees for Martian flows, which tend to have low aspect ratios (e.g.  $h/w = 0.005$  on Olympus Mons).

**Flow margin convolution (2):** This technique uses the fractal dimension (a parameter which measures flow margin convolution) to distinguish between basaltic a'a and pahoehoe lavas, as the pahoehoe margins are more convoluted (Fig. 2). However, measuring the fractal dimension requires the lava flow margins to be sufficiently long, clearly exposed, and unaffected by large-scale topographic controls.

**Flow-field growth characteristics (3):** Studies of terrestrial lavas suggest that flow field growth is systematic and that a general, normalized relation can be established linking the final dimensions of a flow field to underlying slope and eruption duration, independent of explicit knowledge of rheological characteristics, lava density, and gravity. Using this relation (Fig. 3), the effusion duration (and average effusion rate and flow velocity) can be calculated from measurements of flow length, maximum width, average thickness, and ground slope on Mars, assuming that flow growth patterns are similar on Earth and Mars. This technique is only applicable to a'a and blocky flows; the growth of pahoehoe lavas is fundamentally different (3). This technique requires a well-exposed flow for which the vent area can be identified.

Ideally, all three techniques should be applied to the same flow. Realistically, it is often difficult to find flows for which the current data meet all the above requirements. However, if we assume that morphologically similar flows in the same area have similar compositions, we can combine measurements of several such flows. In particular, we can use distal flow lobe widths from several flows to determine the most likely composition for lavas of a particular area. If the distal flow lobe widths indicate a basaltic composition, it is then possible to use flow margin convolution measurements to determine whether the flow was emplaced as a'a or pahoehoe. If, in turn, the fractal dimension of the flow margin falls in the a'a range, we can infer flow growth characteristics according to the flow growth model to better understand flow emplacement.

Similarly, if the distal flow lobe width measurements suggest a more silicic composition, the flow growth model can also be applied. Often, however, because of the overlap between compositional ranges as shown in Fig. 1, the distal flow lobe widths are not conclusive. We are currently developing the flow margin convolution technique to distinguish between flows of different compositions (4).

Alba Patera has several well-defined flows which are suitable for these measurements. Distal flow lobe widths measured from morphologically similar flows fall in the ranges of basaltic to basaltic andesitic compositions as defined by Wadge and Lopes (2) shown in Fig. 1. Additional data to support a basaltic composition is provided by the flow margin convolution technique. Measurements of 4 flow margins (2 flows) were made. All four are fractal, indicating a basaltic composition. Furthermore, the fractal dimensions, ranging from 1.054 to 1.066, indicate an a'a morphology. This justifies the use of the flow growth model, which show these flows had durations in the range of 3.7 to 132 days and effusion rates in the range of  $0.7\text{--}89 \times 10^3 \text{ m}^3 \text{ s}^{-1}$  (5).

## THREE COMPLEMENTARY TECHNIQUES: Lopes-Gautier, R., et al.

These results for Alba Patera illustrate how these three techniques can be used in combination to characterize extra-terrestrial lavas. We are continuing our investigation by measuring other extra-terrestrial flows, as well as by improving the techniques themselves.

References: (1) Wadge, G. and R.M.C. Lopes (1991), *Bull. Volcanol.* **54**, 10-24; (2) Bruno, B.C. et al. (1992), *Geophys. Res. Lett.* **19**, 305-308; (3) Kilburn, C.R.J. and R.M.C. Lopes (1991), *J. Geophys. Res.*, **96**, B12, 19,721-19,732; (4) Bruno, B.C. et al. (1993), this volume; (5) Lopes, R.M.C. and C.R.J. Kilburn (1990), *J. Geophys. Res.*, **95**, B9, 14,383-14,397.

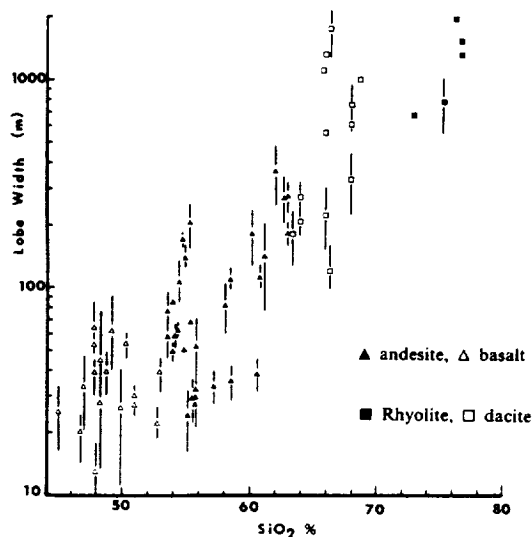


Fig. 1: Plot of average distal flow lobe width (units are log 10 x m) with one standard deviation error bars vs. silica content for terrestrial lava flows. (From 1).

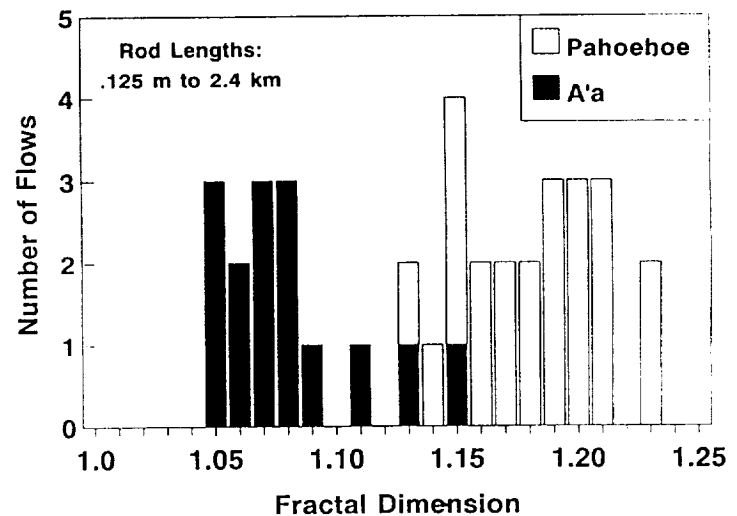


Fig. 2: Histogram of fractal dimension of terrestrial basaltic flows. Alba Patera flows fall in the range 1.054-1.066, characteristic of a'a lavas.

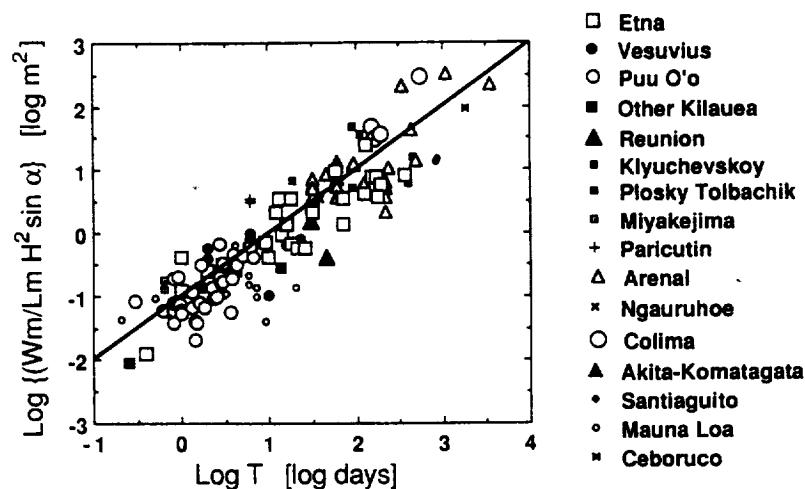


Fig. 3: Relation between final flow field dimensions (max length, Lm; max width, Wm, average thickness, H), underlying slope (alpha) and eruption duration (T). The solid line represents the model trend. (From 3).